BULLETIN 651 JUNE, 1944

Insect Pests of Strawberries in Ohio

Ralph B. Neiswander

OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

This page intentionally blank.

CONTENTS

This page intentionally blank.

INSECT PESTS OF STRAWBERRIES IN OHIO

RALPH B. NEISWANDER

INTRODUCTION

Among the fruit crops grown in Ohio, strawberries are exceeded in value only by apples, peaches, and grapes. The annual farm income from berries sold sometimes exceeds $1,000,000.00. In view of the importance of the crop to Ohio agriculture it is appropriate that attention be given to the relatively long list of insect enemies.

As a general practice, a standard spraying schedule for strawberries is not necessary in Ohio. Some of the more troublesome insects can be held in check by cultural practices and others appear only sporadically and in localized areas. However, severe damage often results when control measures are not applied at the proper time.

It is the purpose of this bulletin to help growers to identify and to combat these pests and also to record the results of recent investigations by the Department of Entomology on some of the more troublesome ones.

THE STRAWBERRY LEAF ROLLER,
ANCYLIS COMPTANA FRAGARIAE (W & R)

The strawberry leaf roller has been widely distributed throughout Ohio for many years, but it was not a troublesome pest until 1934. An outbreak occurred in southwestern Ohio that year and since that time the insect has caused commercial damage in some part of the State each year. The most

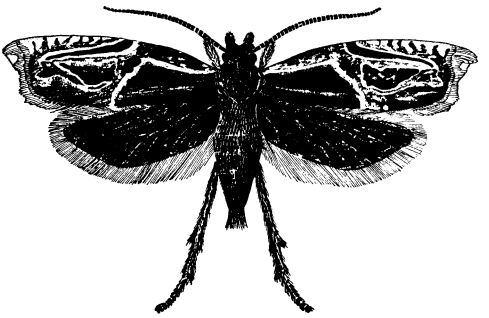

Fig. 1.—Strawberry leaf roller moth.
(Drawing by R. W. Rings)

severe damage has occurred in Montgomery County where counts have shown as high as 76 per cent of the leaflets damaged by larvae of the first brood (19). On October 23, 1940 a record of 226,000 folded leaflets per acre was obtained in a planting of the Premier variety.

A DESCRIPTION OF THE INSECT AND ITS WORK

Strawberry leaf roller adults (fig. 1) are beautifully colored, reddish-brown moths that measure approximately ½ inch from wing tip to wing tip. They deposit tiny, translucent eggs on the strawberry foliage, usually on the under side of the leaves. The larvae which issue from the eggs cause the damage by feeding on the leaf tissue.

In the early stages a larva may feed on either side of a leaf, but as it becomes larger it usually works on the upper surface, where, by means of fine silken threads, it folds the leaflet at the midrib and feeds inside the enclosure thus produced (fig. 2). The epidermis only is devoured, but eventually the entire leaflet turns brown and dies. Sometimes two adjacent leaflets are tied together, and, in case of a heavy infestation, an entire leaf or even several leaves may be webbed together indiscriminately. Sometimes newly formed leaves are attacked and webbed together before they unfold.

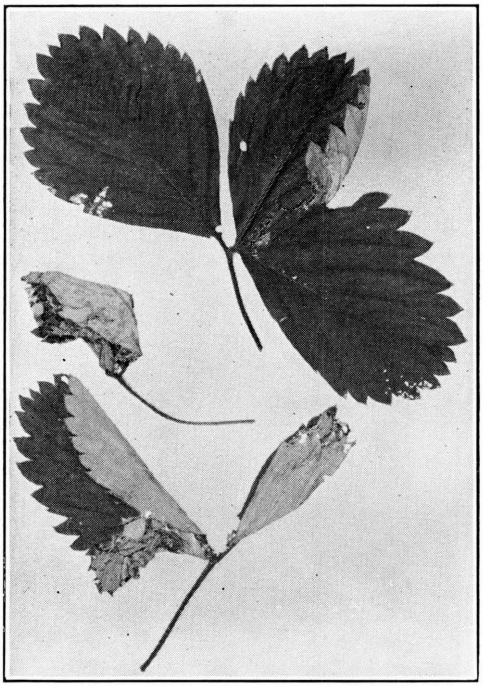

Fig. 2.—Strawberry leaf roller injury.

Young larvae are usually pale green in color but change to gray-brown as they approach maturity. A full grown larva measures approximately ½ inch in length. It changes to a yellowish-brown pupa, which remains inside the folded leaf until the moth emerges.

LIFE HISTORY

In order to study the life history of the strawberry leaf roller it was reared in an insectary at Wooster for 2 consecutive years beginning in the spring of 1936. Two full broods and a partial third appeared during both seasons. Approximately one-third of the second-brood larvae and all of the third entered hibernation. The first two broods were quite distinct in the insectary as well as in the field. An interval of from 2 to 3 weeks occurred between the time when larvae of the first brood stopped working and those of the second brood appeared. No very definite break appeared between the second and third broods.

MOTH EMERGENCE

The periods of moth emergence during three seasons for those moths that emerge from hibernation (designated as the "spring brood") and two seasons for the first and second broods are shown in figure 3. The time of the season when spring-brood moths appear varies greatly. The unusually high temperatures during March and April of 1938 resulted in an unusually early emergence that year. First- and second-brood moths, however, emerged at a somewhat more uniform time both years.

Observations made in the field substantiate these records. Spring-brood moths usually appear during May; first-brood moths during July and the fore part of August; and second-brood moths during the latter part of August and the first few days of September.

EGG DEPOSITION

The number of eggs deposited by leaf roller moths and the length of time moths remain alive depend largely on environmental conditions. Spring-brood moths usually live longer and lay more eggs than do those of the later broods. Likewise, the most severe damage that occurs in strawberry fields is usually caused by larvae of the first brood.

Egg laying begins approximately 2 days after moths have emerged. The length of the oviposition period for the spring brood, first brood, and second brood was 11.4, 10.6, and 7.5 days, respectively. The average number of eggs laid was 80.0, 53.3, and 42.6, respectively. The maximum number of eggs deposited by one female was 157. In breeding cages the average length of life for females of all broods was 15 days, as compared with 14 days for males.

INCUBATION PERIOD

The length of time required for incubation was determined for 4668 eggs. The length of this period varied with temperatures. It was relatively long in the spring, but, as the season advanced and the weather became warmer, the incubation period grew shorter. The average for the first brood was 10.8 days; for the second brood, 8.6 days; and for the third brood, 7.8 days.

COMBINED LARVAL AND PUPAL PERIOD

The length of time that elapsed between the hatching of the egg and the emergence of the moth, for those which did not enter hibernation, was determined for 1261 individuals. The length of this period varied from 27 to 63 days. The average for the first brood was 40.1 days and for the second brood 35.3 days.

The length of this period for those individuals which hibernated was determined for 36 individuals of the second brood and for 42 of the third brood. The averages for the two broods were 289.4 and 255.1 days, respectively. The length of this period depends largely on the time when warm weather appears in the spring, as indicated in figure 3.

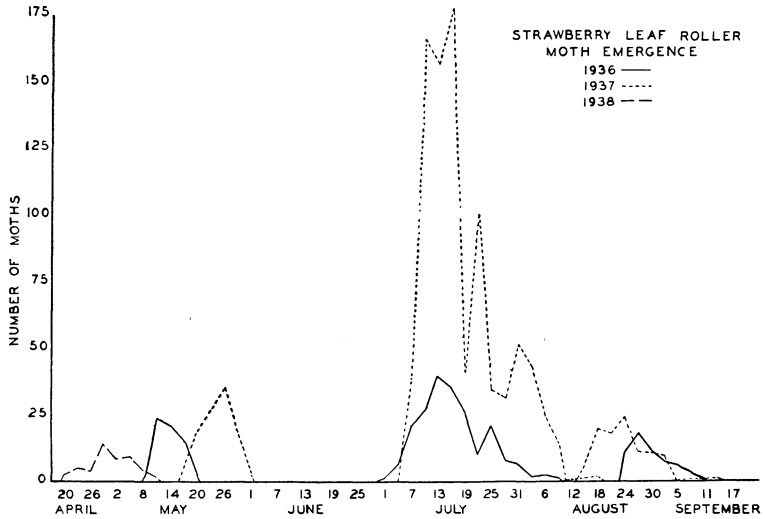

Fig. 3.—Periods of moth emergence during three seasons for the spring brood and two seasons for the first and second broods.

PUPAL PERIOD

Inasmuch as a mature larva usually transforms into a pupa in the place where it completes its feeding, it was necessary to open the folded leaflets in order to determine the time of pupation. It seemed probable that this procedure might influence the development of the insect. Consequently, the length of the pupal stage was determined for a relatively small number of individuals. The average length of the pupal stage for 107 pupae of the first brood was 9.6 days and for 34 pupae of the second brood was 9.3 days.

LENGTH OF LIFE CYCLE

The length of the entire life cycle for the first brood, determined by combining the preoviposition, the incubation, and the combined feeding and pupal periods, was 53.7 days. For those individuals of the second brood which did not hibernate, the length of the life cycle was 46.3 days. It is interesting to note that each stage in the life cycle became shorter as the season advanced and the weather became warmer. However, in spite of the fact that warm weather hastens development, the moths of the spring brood lived longer and produced more offspring than did those of the later broods.

PARASITIZATION

The extent to which the strawberry leaf roller is attacked by parasites has been studied for nine consecutive seasons. This was done by collecting larvae in strawberry fields and rearing them to maturity in cages. Hibernating larvae were usually collected in the fall, sometimes in considerable numbers, and carried over winter in an outdoor, unheated insectary.

The average parasitization for each brood is shown in table 1. The relative number of parasites obtained varied greatly from year to year, but it has never been sufficiently high to effect a commercial degree of control.

TABLE 1.—Parasitization of the strawberry leaf roller

Summary of all records taken

Year	First brood		Second brood		Hibernating brood*	
	Total emergence	Per cent parasites	Total emergence	Per cent parasites	Total emergence	Per cent parasites
1935	84	22.6	123	11.4	191	16.2
1936	606	21.8	847	18.7	30	13.3
1937	441	6.1	71	7.0	96	0
1938	1014	10.7	72	11.1	3854	13.9
1939	241	10.0	204	9.3	3839	25.9
1940	1009	17.2	153	28.1	8915	18.0
1941	338	25.4	502	10.4	4519	6.3
1942	73	11.0	140	15.7	.....	.....
1943	909	14.3	1559	21.4	.....	.....
Average	.....	15.4	.....	14.8	.....	13.4

*Note: Larvae were collected the year indicated, but emergence was recorded the following spring.

Two parasites which attack the larvae were taken in larger numbers than any others. These were *Macrocentrus ancylivorus* Roh. and *Cremastus cookii* Weed. Although these parasites vary greatly in abundance from season to season, they have been responsible for approximately 70 per cent of the total parasitism. Usually *C. cookii* was more effective against the summer broods; whereas *M. ancylivorus* was reared in larger numbers from hibernating larvae.

These two species have been released in considerable numbers in strawberry plantings throughout the State. Many individuals of both species were obtained from New Jersey through cooperation with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. *M. ancylivorus*, which is the most effective parasite of the Oriental fruit moth,

TABLE 2.—Parasites released in strawberry plantings for the control of the leaf roller

Year	Number *M. ancylivorus*	Number *C. cookii*
1935	132	.....
1937	79	.....
1938	391	.....
1939	2024	5276
1940	2317	2756
1941	2362	5622
1942	1171	.....
Total	8476	13,654

has also been reared at the Ohio Agricultural Experiment Station as an important part of the project in fruit moth control. The numbers of both species that were released in strawberry plantings each year are shown in table 2.

The small colony of *M. ancylivorus* that was released in 1935 was placed in a strawberry planting that adjoined a peach orchard in Montgomery County. This colony multiplied rapidly. In 1936 and 1937 *M. ancylivorus* was an effective parasite of the Oriental fruit moth in that locality and it attacked the leaf roller in considerable numbers. During the 6 succeeding years, 7381 *C. cookii* and 7457 *M. ancylivorus* were released in the strawberry fields of Montgomery County, but leaf roller parasitization did not build up and the leaf roller has continued to cause damage in that locality.

TABLE 3.—Strawberry leaf roller parasites recorded in Ohio

Species	Order	Family
Agromyza setosa Loew	Diptera	Agromyzidae
Anachaetopsis tortricis (Coq.)	Diptera	Tachinidae
Ascogaster quadridentatus Wesm.	Hymenoptera	Ichneumonidae
Bassus annulipes (Cress.)	Hymenoptera	Braconidae
Cremastus cookii Weed	Hymenoptera	Ichneumonidae
Ephialtes inflatus (Twns.)	Hymenoptera	Ichneumonidae
Epiurus indagator (Cress.)	Hymenoptera	Ichneumonidae
Eurytoma tylodermatis Ashm.	Hymenoptera	Eurytomidae
Goniozus platynotae Ashm.	Hymenoptera	Braconidae
Hoplocryptus incertulus Cush.	Hymenoptera	Ichneumonidae
Ischnus polychrosidis (Cush.)	Hymenoptera	Ichneumonidae
Itoplectus conquisitor (Say)	Hymenoptera	Ichneumonidae
Macrocentrus ancylivorus Roh.	Hymenoptera	Braconidae
**Mesochorus* sp.	Hymenoptera	Ichneumonidae
Microbracon caulicola Gah.	Hymenoptera	Braconidae
Microbracon gelechiae (Ashm.)	Hymenoptera	Braconidae
Microbracon politiventris (Cush.)	Hymenoptera	Braconidae
Microgaster comptanae Vier.	Hymenoptera	Braconidae
Microgaster epagoges Gah.	Hymenoptera	Braconidae
Nemorilla floralis (Fallen)	Diptera	Tachinidae
Oncophanes atriceps (Ashm.)	Hymenoptera	Braconidae
**Perilampus fulvicornus* Ashm.	Hymenoptera	Perilampidae
**Perilampus granulosus* Cwfd.	Hymenoptera	Perilampidae
Perisierola sp.	Hymenoptera	Bethylidae
Spilochalcis torvina (Cress.)	Hymenoptera	Chalcididae

*Secondary parasites.

Twenty-five parasite species (table 3) have been reared from the strawberry leaf roller in Ohio. Except for the two species already discussed none has been taken in sufficient numbers to indicate economic importance. In 1938 the dipterous parasite, *Anachaetopsis tortricis* (Coq.), was reared from hibernating larvae in larger numbers than any other parasite species, but it parasitized less than 10 per cent of the larvae collected and in no other case has it been taken in significant numbers.

Although folded strawberry leaflets were not opened to determine the stage of the host when the collections were made, by far the major portion were in the larval stage. The extensive collections of hibernating insects were taken in late fall when the pupal stage does not occur. Consequently, relatively few of the host insects studied had been exposed to pupal parasites; it is quite probable that such parasites were more numerous than the records indicate.

CONTROL STUDIES

Commercial leaf roller damage has occurred in the strawberry fields of southwestern Ohio each year since 1934. The damage has been most consistent and most severe in the extensive plantings immediately north of Dayton. The soil in this locality is such that young strawberry plants grow vigorously and provide favorable conditions for the development of leaf roller larvae.

Inasmuch as lead arsenate has been recommended (10, 12, 17) for the control of this insect, growers in Montgomery County sprayed their strawberry plantings with this material in both 1934 and 1935, but they were dissatisfied with the results. Consequently, a research project for the control of the leaf roller was inaugurated in 1936 and was continued for six consecutive seasons. Field insecticidal studies were carried on each year, except 1940. The project was discontinued in 1942, but a cooperative experiment was arranged with a fruit grower in 1943.

The Premier variety, which is widely grown and which has been damaged more severely than other of the common varieties, was usually employed in field tests. In all cases, the insecticidal treatments were applied in five replications distributed over the experimental area. Plots were always three rows wide and approximately 30 feet long. The five plots employed in each treatment, therefore, represented approximately 1/25 acre. The tests conducted each year are discussed separately, but, unless otherwise stated, the work was done in a planting set the previous year. Experience has shown that little injury appears in a planting that is 2 years old.

1936 EXPERIMENTS

The 1936 experiments were conducted in a portion of an 11-acre planting in Montgomery County. Treatments were applied on May 12, May 22, and

TABLE 4.—Injured strawberry leaflets in a 600-leaflet sample, June 10, 1936**

Materials	Replications					Mean	Per cent control
	A	B	C	D	E		
*Derris (4% rotenone), 12½ pounds.. Gypsum, 87½ pounds	122	73	124	135	100	100.8	75.7
*Cube (4% rotenone), 12½ pounds... Gypsum, 87½ pounds	197	276	243	246	244	241.2	47.2
*†Black Arrow Dust	215	254	256	240	260	245.0	46.3
‡Dutox, 5 pounds §Dupont Sreader-Sticker, 3 ounces Water, 100 gallons	233	310	284	286	200	262.6	42.5
‖Kalo Spray, 5 pounds Dupont Spreader-Sticker, 3 ounces Water, 100 gallons	74	170	111	78	118	110.2	75.9
Check, no treatment	383	508	416	502	478	456.4	.....

*These materials were applied on May 12, May 22, and May 27. The two remaining treatments shown in the table were applied only on May 12 and May 22.

**This number represents 200 leaves because each strawberry leaf is composed of three leaflets.

†Black Arrow Dust—pyrethrum; McCormick & Co., Baltimore, Md.

‡Dutox—barium fluosilicate and sodium fluoaluminate; E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

§Dupont Spreader-Sticker—sulfated alcohol; E. I. du Pont de Nemours & Co., Wilmington, Del.

‖Kalo Spray—natural cryolite; The Kalo Company, Quincy, Ill.

May 27. Since the earlier berries were showing color on May 27, only those materials which included no poisons were used for the third application.

On June 10 the performance of each treatment was evaluated by counting the folded or injured leaflets of a 600-leaflet sample taken from the center row of each plot, beginning approximately 2 feet from the nearest end. The data are summarized in table 4.

Kalo Spray and Derris dust proved to be the most effective of the insecticides used. The plots treated with these materials were so little injured that they could be detected readily without consulting the label stakes. An analysis of variance showed that both of these materials were significantly more effective than the other three treatments at odds of 100 to 1. Two applications of Kalo Spray appeared just as effective as three applications of Derris dust.

1937 EXPERIMENTS

Early observations made in 1937 indicated that no appreciable injury from strawberry leaf roller was likely to develop in Montgomery County, but during the latter part of May larvae appeared in sufficient numbers to alarm the growers. Consequently, the experimental research program was continued

TABLE 5.—Injured strawberry leaflets in a 600-leaflet sample, August 18, 1937

Materials	Replications					Mean	Per cent control
	A	B	C	D	E		
Kalo, 5 pounds Dupont Spreader-Sticker, 2 ounces.. Water, 100 gallons	0	4	40	16	11	14.2	89.3
*Alorco Cryolite, 5 pounds Dupont Spreader-Sticker, 2 ounces.. Water, 100 gallons	2	13	9	19	6	9.8	92.6
†Red Arrow, 2 parts ‡Orthol K, 4 parts Water, 100 gallons	33	33	12	58	34	34.0	74.3
Phenothiazine, 3 pounds Water, 100 gallons	95	73	42	64	21	59.0	55.4
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	10	10	16	10	12	11.6	91.2
§Dry Pyrocide, 1 part Talc, 9 parts	34	32	16	28	43	30.6	76.9
Kalo, 1 part Talc, 2 parts Flour 2 parts	11	6	4	9	6	7.2	94.6
Dutox, 1 part Talc, 2 parts Flour, 2 parts	3	16	1	4	8	6.4	95.2
Kalo, 3 parts Talc, 6 parts	5	20	13	8	4	10.0	92.4
‖Kryocide, 1 part Talc, 3 parts Flour, 2 parts	5	4	10	8	2	5.8	95.6
Check, no treatment	171	119	82	220	70	132.4	.....

*Alorco—synthetic cryolite; Aluminum Ore Co., East St. Louis, Ill.
†Red Arrow—pyrethrum; McCormick & Co., Baltimore, Md.
‡Orthol K—summer spray oil; California Spray-Chemical Corporation, Berkeley, Calif.
§Dry Pyrocide—pyrethrum; McLaughlin Gormley King Co., Minneapolis, Minn.
‖Kryocide—natural cryolite; Pennsylvania Salt Mfg. Co., Philadelphia, Pa.

and on June 3 and 4 several materials were used in one application on small replicated plots. Records taken on June 17 showed that Red Arrow, Kalo Spray, and Dry Pyrocide dust had each effected more than a 50 per cent control, but the differences among these materials were not sufficient to be considered significant. All of the insecticides mentioned above, however, proved more effective than powdered Derris root.

Tests against the second brood were conducted in a heavily infested planting in Ashland County. Ten treatments and a check were employed and three applications of each material were made at weekly intervals beginning July 15, when the earliest of the second-brood eggs were hatching.

Seven of the 10 insecticidal treatments included fluorine as the toxic agent.

On August 18, injured strawberry leaflets were counted in a 600-leaflet sample taken near the center of each plot. The data obtained are summarized in table 5. All of the fluorine combinations were very effective, whether used as dusts or sprays, and the differences in the degree of control produced were not sufficient to be significant. All proved more effective than any of the other three combinations tested.

Although Kalo Spray appeared significantly more effective than Dutox in 1936 when both were used as sprays, in 1937 Dutox dust appeared as effective as Kalo when the latter was used both as a dust and as a spray. The part of the planting not included in the experimental plots comprised approximately ¾ of an acre. This area was sprayed with the first formula listed in table 5. Leaf counts made in this area on August 18 showed a very effective control. Less injury was evident than in any of the small replicated plots.

1938 EXPERIMENTS

In 1938, moths and eggs were observed in considerable numbers in the strawberry planting in Ashland County during the first few days of May. Consequently, a series of insecticidal tests were arranged and one application of each material was made on May 5. However, no appreciable injury developed and no more applications were made. Although leaf roller injury was somewhat lighter in the treated plots than in the checks, the infestation proved too light to yield significant results. No appreciable leaf roller injury has appeared in that locality since 1937.

1939 EXPERIMENTS

Control experiments were again carried on in the Dayton area in 1939 where the leaf roller population was much higher than it was in 1937. The work was done in a planting that was set in 1938, which adjoined one set in 1937. The two areas comprised approximately 30 acres.

Nine insecticidal treatments and a check were employed against the first brood. Two applications of each material were made, one on May 18 and the other on May 25. The treatments were evaluated on June 7 by counting the injured leaves in a sample of 150 taken near the center of each plot. The data are summarized in table 6. A difference between means of 22.3 was found to be significant at odds of 19 to 1. The Alorco Cryolite dust proved significantly better than Dutox spray, and better than the Kryocide spray at 3 pounds per

100 gallons. It is interesting to note also that all other treatments were significantly better than Dry Pyrocide dust and that the Orthol K-lead arsenate combination proved very effective (16).

TABLE 6.—Injured strawberry leaves in a 150-leaf sample. June 7, 1939

Materials	Replications					Mean	Per cent control
	A	B	C	D	E		
Dry Pyrocide, 1 part Talc, 9 parts	65	71	102	72	79	77.8	15.1
Orthol K, 2 quarts *Black Leaf 40, 1 pint Water, 100 gallons	18	20	45	34	78	39.0	57.4
Kryocide, 1 part Talc, 4 parts	19	51	20	31	47	33.6	63.3
Kryocide, 5 pounds Dupont Spreader-Sticker, 2 ounces. Water, 100 gallons	17	24	28	51	20	28.0	69.4
Kryocide, 3 pounds Dupont Spreader-Sticker, 2 ounces., Water, 100 gallons	40	21	58	59	48	45.2	50.7
Dutox, 5 pounds Dupont Spreader-Sticker, 2 ounces. Water, 100 gallons	46	28	56	30	72	46.4	49.3
Lead arsenate, 4 pounds Ortol K, 1 quart Water, 100 gallons	29	28	30	17	18	24.4	73.4
Derris (4% rotenone), 1 part Talc, 7 parts	9	18	42	66	52	37.4	59.2
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	28	26	3	24	21	20.4	77.7
Check, no treatment	84	123	110	83	58	91.6	....

*Black Leaf 40—nicotine sulphate; Tobacco By-Products and Chemical Corporation, Louisville, Ky.

Berries were being picked when the counts were made on June 7. Samples were taken from the Kryocide-dust plots and from the plots sprayed with Kryocide at the rate of 5 pounds in 100 gallons in order to determine the fluorine residue. The samples were analyzed by the Food and Drug Administration and the following is quoted from the report received: "The added fluorine seems to vary from nothing to possibly 1.5 p. p. m. or .010 gr/lb. Since the fluorine tolerance is now .02 gr/lb., the spray residue found on these berries is not at all alarming."

Experiments for the control of second-brood leaf rollers were carried on in the same locality in a planting set in the spring of 1939. The plants were small when the treatments were applied, but the injury was rather severe. Two applications were made, the first on June 29 and the second on July 7. Frequent rains occurred during this period. The plants were growing vigorously and new leaves soon appeared after each treatment which were not coated with insecticide.

Infestation records were taken on July 21 by counting the injured leaflets in a 600-leaflet sample and also by opening the folded leaflets and counting the living larvae in 100 leaves. The samples for both counts were taken near the center of each plot. The two records correspond closely. The data obtained by the latter method are shown in table 7.

TABLE 7.—Living larvae found in samples of 100 strawberry leaves. July 21, 1939

Materials	Replications					Mean	Per cent control
	A	B	C	D	E		
Kryocide, 5 pounds Dupont Spreader-Sticker, 2 ounces.. Water, 100 gallons	2	15	20	9	16	12.4	63.1
Kryocide, 3 pounds Dupont Spreader-Sticker, 2 ounces.. Water, 100 gallons	17	29	21	31	3	20.2	39.9
Orthol K, 1 quart Lead arsenate, 4 pounds Water, 100 gallons	20	13	4	16	12	13.0	61.3
Alorco Cryolite, 5 pounds Dupont Spreader-Sticker, 2 ounces.. Water, 100 gallons	10	4	12	16	11	10.6	68.5
Kryocide, 1 part Talc, 4 parts	3	9	10	3	5	6.0	82.1
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	5	5	11	18	5	8.8	73.8
Kryocide, 1 part Talc, 2 parts Flour, 2 parts	12	9	10	2	12	9.0	73.2
Check, no treatment	38	42	39	29	20	33.6	.....

It is interesting to note that dusts bearing fluorine appeared more effective than sprays containing the same material. Although the degree of control obtained in 1939 was not as high as that of 1937, it should be noted that the population was larger in 1939 and that only two applications were made that year whereas three were made in 1937.

1940 EXPERIMENTS

No detailed spraying experiments were conducted in 1940. A grower in the Dayton area tested two applications of Kryocide at 5 pounds in 100 gallons and two of the lead arsenate-Orthol K combination, as shown in table 7, against the second brood. Since no untreated checks were available for comparison the degree of control obtained could not be determined and the differences between treatments were not significant. However, rather wide differences in degree of infestation were observed between varieties. For example, on July 30 an examination of five samples of 100 leaves each in the Premier variety yielded an average of 51.8 folded leaflets and 42.6 living larvae per 100 leaves. On the same date, three samples of 100 leaves each in the Catskill variety yielded an average of 17 folded leaflets and 13 living larvae per 100 leaves. Samples in both cases were taken from a planting that had been sprayed with Kryocide.

On October 23, population counts made in seven widely distributed points in the same Premier planting showed 122.1 folded leaflets per 100 leaves and 226,700 folded leaflets per acre. On the same date, counts made in the same manner in the Catskill variety showed 51.3 folded leaflets per 100 leaves and 122,500 folded leaflets per acre.

On October 22, counts made in the same manner in another planting showed the following populations expressed in folded leaflets per acre: Aroma—89,450; Blakemore—72,250; and Premier—109,680.

These records substantiate previous observations in that strawberry plants of the Premier variety are usually more severely damaged by the leaf roller than are other common varieties. This may be due in part to the texture of the leaves, since those of Premier are smaller and lighter in texture than the leaves of the other varieties studied.

The leaf texture may also be partly responsible for the fact that in general new plantings of any variety which are growing vigorously are more severely damaged than are older plantings.

1941 EXPERIMENTS

Spraying and dusting experiments for the control of the leaf roller were again conducted in the Dayton area in 1941. The first-brood population was again quite large. The program included eight formulae and a check; the first application was made May 8. No folded leaflets were observed on that date but many eggs and newly hatched larvae were seen. A second application of all materials was made on May 15. Four treatments were applied again on May 23, in spite of the fact that the earliest berries were ripening. The data are summarized in table 8.

TABLE 8.—Injured leaflets per 100 leaves found in samples of 400 leaves taken June 4, 1941

Materials	Replications					Mean	Per cent control
	A	B	C	D	E		
*†NNOR, 1.6 pints Water, 100 gallons	158	214	227	166	94	171.8	0
‡GeniCide, 2 pounds §Genifilm C, 1 pound Water, 100 gallons	158	184	213	140	170	173	0
*Orthol K, 1½ gallon Black Leaf 40, ⅔ pint Water, 100 gallons	55	82	36	61	52	57.2	65.0
Lead arsenate, 4 pounds Orthol K, ½ gallon ‖C.P.O. soap, 6 ounces Water, 100 gallons	72	73	92	63	79	75.8	53.6
Alorco Cryolite, 5 pounds Dupont Spreader-Sticker, 2 ounces Water, 100 gallons	127	68	63	123	79	92	43.8
*Kryocide, 5 pounds Dupont Spreader.Sticker, 2 ounces Water, 100 gallons	63	36	23	33	59	42.8	73.8
Kryocide, 1 part Talc, 2 parts Flour, 2 parts	149	119	118	107	64	111.4	31.9
*Kryocide, 5 pounds C.P.O. soap, 12 ounces Water, 100 gallons	22	61	42	21	35	36.2	77.9
Check, no treatment	155	127	192	188	156	163.6	.....

*Note: These materials were applied on May 8, May 15, and May 23. All others were applied only on May 8 and May 15.

†NNOR—rotenone and technical mannitan monolaurate; Atlas Powder Co., Wilmington, Del.

‡GeniCide—Dibenzo gamma pyrone; General Chemical Co., 40 Rector St., New York City.

§Genifilm C—a spreader; General Chemical Co., 40 Rector St., New York City.

‖C. P. O. Soap—a soap spreader; Soap and Chemical Co., Inc., 6300 State Road, Philadelphia, Pa.

The NNOR and GeniCide treatments appeared ineffective against the leaf roller and the GeniCide caused rather severe burning.

The two Kryocide sprays were arranged to test the influence of the type of soap used, but the differences were not sufficient to be considered significant. Both seemed better than the oil and nicotine combination, although the differences may not be significant, since at odds of 19 to 1 a difference between means of 41.8 is necessary for significance.

1943 EXPERIMENTS

Early in the season when leaf roller populations are heaviest, fruit growers are busy with other things and can not always take the time necessary to spray or dust strawberries often enough to obtain satisfactory control. Often it has been observed during late summer that a leaf roller population builds up rapidly in a planting set in the spring of the same year but it decreases in older plantings. The hibernating population observed in the fall is usually concentrated on the planting set during the current year.

These observations suggested the possibility that commercial damage might be avoided during the following year if the hibernating population on the young planting could be largely eliminated. Consequently, in 1943 a cooperative experiment was arranged with a grower in Montgomery County whose strawberries were heavily infested. The planting set in the spring of 1943 was sprayed by the grower three times at weekly intervals beginning August 17. The planting consisted of approximately 3 acres. Half of it was sprayed with Alorco Cryolite and the remainder with a lead arsenate-oil combination. On September 14 and again on October 29 the living larvae in 100 consecutive leaves were counted in 10 widely distributed samples in each area. Similar counts were made also in the nearest neighboring planting owned by Mr. C. E. Arnold and in a second planting approximately 10 miles distant owned by Mr. C. S. Mumma which had carried a spring-brood population similar to that in the experimental area. The materials used and the data obtained are summarized in table 9.

TABLE 9.—Summary of strawberry leaf roller infestation counts. 1943. (Average of 10 samples)

Treatment	Average number living larvae per 100 leaves	
	September 14	October 29
Lead arsenate, 4 pounds *Superla, ½ gallon †Duponol OS, 2 ounces Water, 100 gallons	6.3	2.9
Alorco Cryolite, 5 pounds Dupont Spreader-Sticker, 2 ounces Water, 100 gallons	4.2	3.1
Arnold planting (not treated)	23.5	16.6
Mumma planting (not treated)	32.9	28.8

*Superla—summer spray oil; The Standard Oil Company (Indiana), 910 South Michigan Ave., Chicago, Ill.

†Duponol OS—an oil soluble emulsifying and wetting agent; E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

The counts made on September 14, as recorded in table 9, as well as previous observations, indicated that the sprays containing cryolite were slightly more effective than those containing lead arsenate, but no significant difference was evident on October 29. A deposit of lead arsenate was still visible on October 29 and it seems probable that the Duponol-oil combination, which serves as a load builder, made the lead arsenate effective over a long period of time.

Although the data are not sufficiently comprehensive to permit adequate analysis, it is evident that the hibernating population was much reduced. Counts made in a planting set in 1942 which adjoined the experimental plots showed a population of but four larvae per 1000 leaves on October 29.

GENERAL DISCUSSION OF THE RESULTS OF EXPERIMENTAL CONTROL STUDIES ON THE STRAWBERRY LEAF ROLLER. 1936-1943

In a study of the insecticidal tests that have been completed, cryolite (either natural or synthetic) stands out as an economical and a consistently effective material. In four out of five tests in which it was used both as a dust and a spray the dust yielded better results. The differences in any one year were not sufficient to be highly significant, but it was only when rains followed soon after the first two applications of dust that an application of spray was more effective.

For dusting purposes, cryolite seems most satisfactory when diluted with 2 parts talc and 2 parts flour. If applied as a spray approximately 5 pounds should be used in 100 gallons and a suitable sticker and spreader should be included.

The combination of lead arsenate and oil proved effective also and when combined with a sticker and spreader such as Duponol it seems as satisfactory as cryolite although somewhat more expensive. The lead-oil-sticker combination that was most satisfactory consisted of 4 pounds lead arsenate, ½ gallon summer oil, and 2 fluid ounces of Duponol in 100 gallons.

The data indicate that three thorough applications at weekly intervals are necessary to obtain commercial control when the leaf roller population has reached damaging proportions. Such control was obtained most economically by treating the new planting only and by beginning during the latter part of August.

CONTROL MEASURES RECOMMENDED FOR STRAWBERRY LEAF ROLLER

When the strawberry leaf roller causes commercial damage, spray or dust those plantings set during the current season in order to destroy the hibernating population. Make three thorough applications at weekly intervals beginning about August 20. For dusting purposes, mix 1 part cryolite with 2 parts talc and 2 parts flour. If a spray is more desirable, use 5 pounds of cryolite in 100 gallons of water and include a suitable spreader such as sulfated alcohol, potash fish oil soap, or goulac.

If the hibernating population has not been eliminated and damage by the spring brood is anticipated, trouble can be largely avoided with two or three insecticidal applications at weekly intervals. The first spray or dust should

be applied when the first eggs are hatching, which usually occurs early in May. However, in order to avoid a poisonous residue on the berries, at least 2 weeks should elapse before the first picking after cryolite or lead arsenate has been applied. If an insecticide is needed when the berries are ripening, a spray containing 1 gallon of summer oil and ⅔ pint Black Leaf 40 in 100 gallons, or a dust containing .5 per cent rotenone may be used.

STRAWBERRY ROOTWORMS

Two species of strawberry rootworms are often found in considerable numbers attacking strawberry plants in Ohio. The two species of larvae are very similar and as yet no characteristics have been pointed out by which they can be readily distinguished. When mature, they measure about 1/6 inch in length and resemble miniature white grubs. The mature larvae construct tiny cells an inch or two below the surface of the soil in which they transform to pupae and later to adults.

The adults emerge from the soil and feed on the foliage, where they usually cause more damage than that which appears on the roots. The adult beetles of the two species can be distinguished at a glance, and, since the larvae appear at different times of the year, one can be reasonably sure which species is responsible for damage when they are sufficiently abundant to cause trouble. In the adult stage these two rootworms are known as the strawberry leaf beetle and as the grape colaspis.

THE STRAWBERRY LEAF BEETLE, *PARIA* SP.

The species that most often causes trouble on strawberries in Ohio is *Paria* sp., commonly called the strawberry leaf beetle. It is a shiny, oval beetle usually brown varying to black, with four darker blotches on the wing covers (fig. 4). It measures slightly more than ⅛ inch in length. The most severe damage is caused by the beetles which eat holes in the leaves. When they become abundant, the leaves are riddled with holes and sometimes plants are killed. (fig. 5).

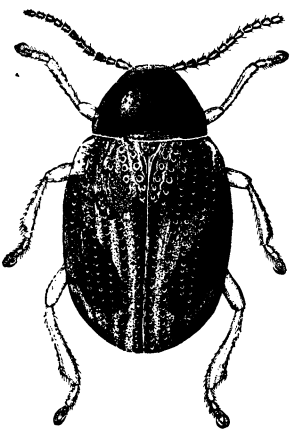

Fig. 4.—*Paria* sp. adult. (Drawing by R. W. Rings.)

The beetles hibernate under mulch, in crevices in the soil, or in other protected places and begin feeding and laying eggs when warm weather appears. The feeding punctures which have been observed in early May gradually become more numerous until the middle of June. The eggs are laid during this period on the older leaves near the ground. As the larvae hatch, they burrow into the ground where they feed on the roots for a period of approximately 2 months. In an effort to determine the depth at which the larvae were feeding, similar samples of soil taken at varying depths were sifted through an 18-mesh screen. All of the larvae found were located within 6 inches of the surface of the soil and 65 per cent were located in the top 2 inches.

Adults of the next generation have been observed as early as July 16, with continued emergence throughout August. The newly emerged beetles feed until fall. The damage caused in late summer and fall is usually more severe than that which appears in the spring.

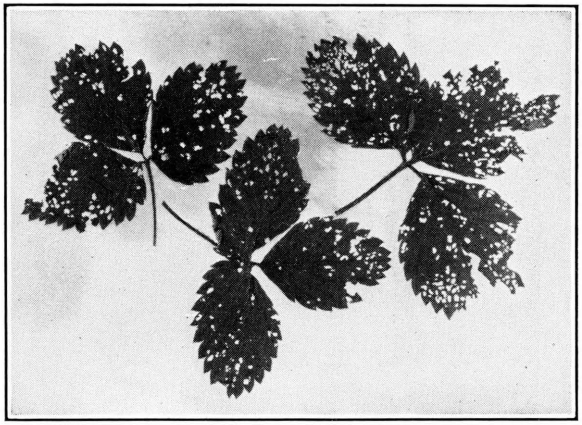

Fig. 5.—Strawberry leaves injured by *Paria* sp. Fab.

The beetles feed chiefly at night and are seldom seen during the day, regardless of the density of the population. They are usually concealed during daylight hours in the litter around strawberry plants or in crevices in the soil. In order to observe them at work, the writer occasionally visited a heavily infested field in the evening and early part of the night during August. No beetles were seen on the foliage while daylight remained, but by 8:45 P. M. they were found readily with the aid of a flashlight. By 9:30 P. M. they were sufficiently abundant that 20 were collected in an area of one square foot. Frequently, as many as three beetles were observed on one leaflet. When disturbed they would quickly fold their legs and drop to the ground as though dead and were immediately concealed in the mulch.

CULTURAL PRACTICES

Strawberry growers who do not attempt to get more than two crops of berries from a planting seldom have trouble with this leaf beetle. The control measures usually recommended (12, 23) state that badly infested fields should be plowed down as soon as the crop is harvested, and new fields should be set at some distance from infested ground. If a planting is permitted to stand for 3 or more years, leaf beetle injury nearly always appears.

In 1941 it was learned that strawberry plantings in Columbiana and Mahoning Counties were damaged severely by the strawberry leaf beetle, in spite of the fact that the growers made no effort to produce more than two crops from a planting. As a result of these observations a control project was planned for 1942.

A farm near Greenford which contained three plantings of strawberries, each comprising more than 5 acres, was selected for study. The first field was

planted in 1940 and suffered considerable damage in 1941, but it showed prospects of producing a fair crop in 1942. The second field adjoined the first and was planted in 1941. This field was in good condition although *Paria* sp. injury was evident in the rows nearest the older planting. The third planting was set in the spring of 1942 and was located at the far end of the farm, approximately 80 rods from the older plantings.

The feeding of the hibernating brood caused severe injury in the older planting, as well as in the part of the second planting nearest it. Soil samples were examined in the older planting on July 8 when the insects were nearly all in the rootworm stage, and as many as 105 were found in a sample 8 inches in diameter and 4 inches deep. Observations made in different parts of the planting indicated that the population was uniformly heavy throughout the area. This would indicate a population of over 13,000,000 per acre. Samples taken in the adjoining field indicated a population of only about 4 per cent of that in the older field.

It was learned from the grower that it was his custom to leave such a planting stand until fall before plowing it down. This of course permitted the larvae to change to the adult stage and spread to desirable hibernating quarters throughout the neighborhood. The need for plowing the field directly after the cropping season was explained to the grower who plowed the field carefully on July 10 and worked the ground thoroughly soon thereafter. Subsequent observations indicated that practically all of the rootworm larvae were killed and that the grower's problem was solved. When the new brood of adults appeared in August some injury developed in the 1941 planting, but it did not become sufficiently severe to cause commercial damage. The planting set in 1942 at the far end of the farm grew vigorously throughout the season and no rootworm injury appeared.

A similar condition was found the same year (1941) in a neighboring farm. A strawberry planting which was set in the spring of 1939 was damaged severely by *Paria* sp. This field was plowed in the fall of 1941, but not until after all beetles had emerged. The grower explained that the damage had been most severe along the north side and was progressively less severe southward. A woodlot adjoined the planting on the north side and a fencerow approximately 10 feet wide separated the woodlot and strawberry field. Much of the area in the fence row was covered with a dense growth of cinquefoil (*Potentilla canadensis* L.), which is closely related to strawberry. The cinquefoil was damaged by *Paria* sp. (fig. 6) and may have served as a reservoir from which the infestation developed in the strawberries. It is more probable, however, that many beetles hibernated in the woodland and moved to the strawberry field so close at hand in the spring.

In 1941 a new planting was set in a field immediately south of that planted in 1939. This field was damaged slightly in 1941 and successively more severely in 1942 and 1943. The damage was again most severe on the north side. It seems evident that many of the beetles that were permitted to emerge in the older planting hibernated successfully in the neighboring woodland and fence rows and concentrated on the strawberries so readily available in 1942. This planting was plowed down soon after the berries were harvested in 1943, and subsequent examinations indicated that most of the larvae were killed.

In the spring of 1942 a new planting was set in close proximity to the 1941 planting. During 1942 and 1943 slight damage occurred in this field in

the area nearest the older planting, but the injury was less severe than that observed in the 1941 planting. It was evident that the population had been greatly reduced by plowing down the old planting while the insect was in the larval stage.

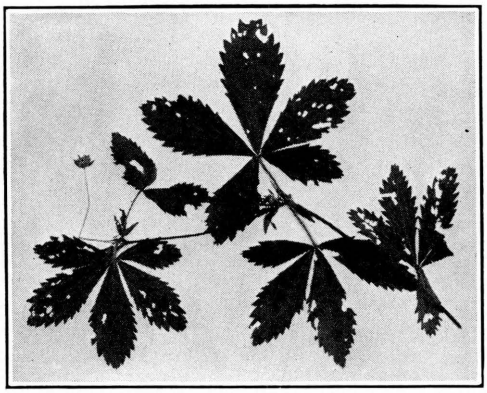

Fig. 6.—Cinquefoil leaves injured by *Paria* sp.

In 1943 a new planting was again set adjacent to the 1942 planting. This field was bordered on the east side and part of the south side by a woodland. During August feeding punctures were more abundant in the area near the woodland than in the rows adjacent to the older planting. The injury was too light to cause damage or to indicate that damage would result in 1944, but the distribution of the feeding punctures indicated that beetles had hibernated successfully in the woodland.

It is evident from these observations that a rootworm population can be greatly reduced by plowing down infested fields in early July while the insect is in the larval stage and that new plantings should be set at some distance from infested fields. They indicate also that favorable hibernating quarters adjacent to a heavily infested field are a menace to a new planting in the immediate vicinity.

INSECTICIDE CONTROL

Soil treatment with lead arsenate is frequently recommended for the control of white grubs, and it seemed probable that such treatment would also be effective against strawberry rootworms. In 1939 a study was made of the leaf beetle injury in a series of small strawberry plots set in 1935 by C. R. Neiswander at the Ohio Agricultural Experiment Station. The plots were employed in a study of lead arsenate treatments for the control of white grubs. The poison was applied in three different strengths and the treatments were replicated four times. An analysis of soil samples made early in 1939 showed that approximately the same quantities of lead arsenate remained in the soil as was applied in 1935.

Feeding punctures caused by the hibernating beetles were observed early in May, and the injury gradually increased as the season advanced. On June 5 counts were made of the feeding punctures in 100 leaves taken at random in each plot. The data obtained are shown in table 10.

TABLE 10.—Numbers of strawberry leaf beetle feeding punctures in 100 leaves recorded June 5, 1939 in each replicate of plots which had received different dosages of lead arsenate as a soil treatment

Lead arsenate per 1000 square feet	Replications				Mean
	A	B	C	D	
None	512	1021	1146	726	851
5 pounds	762	1047	953	901	916
15 pounds	852	1041	949	767	902
25 pounds	876	737	1176	872	915

During the period July 12 to August 5, 1939, an effort was made to determine the number of larvae, pupae, and adults in the soil of the various plots. Five soil samples were taken from each plot and sifted through an 18-mesh screen in order to find the insects. Each sample was 8 inches in diameter and 8 inches deep. The data obtained are presented in table 11.

TABLE 11.—Larvae, pupae, and adults found in five soil samples taken from plots which had received different dosages of lead arsenate as a soil treatment

Lead arsenate per 1000 square feet	Replications				Mean
	A	B	C	D	
None	35	65	162	52	78.5
5 pounds	44	73	38	109	66
15 pounds	29	20	134	83	66.5
25 pounds	5	46	98	111	65

It is evident in tables 10 and 11 that the lead arsenate treatments did not control the strawberry leaf beetle. In spite of high concentrations of lead arsenate in certain plots, the leaf beetle injury was severe and many living insects were found.

SPRAYING AND DUSTING TO CONTROL STRAWBERRY LEAF BEETLE, 1942

In an attempt to find a spray or dust that would control the strawberry leaf beetle, seven insecticidal combinations were tested during the season of 1942. In one planting, they were tested against the hibernating brood in a single application of each material made on May 25. In another planting, they were tested in three applications made August 6, August 12, and August 19, respectively, in an attempt to control the new brood.

In each case treatments were replicated five times and plots including five untreated checks were three rows wide and 30 feet long. The sprays were applied with a knapsack sprayer at the rate of approximately 125 gallons per acre. The dusts were applied with a Feeny hand duster at the rate of approximately 60 pounds per acre.

TABLE 12.—Feeding puncture records taken June 8, 1942 from 50-leaf samples from each replicate of plots sprayed or dusted to control strawberry leaf beetle

Materials used	Replications					Mean
	A	B	C	D	E	
Calcium arsenate, 4 pounds Hydrated lime, 6 pounds Water, 100 gallons	169	119	162	208	158	163.2
Lead arsenate, 4 pounds Volck Concentrate, 1 quart Water, 100 gallons	358	172	133	77	140	176.0
Kryocide, 4 pounds Dupont Spreader-Sticker, 3 ounces Water, 100 gallons	156	243	88	65	127	135.8
Derris (4 per cent), 4 pounds Water, 100 gallons	303	185	150	213	128	195.8
Dutox, 1 part Talc, 2 parts Flour, 2 parts	201	144	37	36	137	105.0
Black Leaf 155, 1 part Talc, 1 part	246	224	186	75	109	168.0
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	170	116	91	80	93	110.0
Check, no treatment	192	194	273	177	124	192.0

TABLE 13.—Feeding puncture records taken September 2, 1942, from 125-leaflet samples from each replicate of plots sprayed or dusted to control strawberry leaf beetle

Materials used	Replications					Mean
	A	B	C	D	E	
Calcium arsenate, 4 pounds Hydrated lime, 6 pounds Water, 100 gallons	1157	1082	1330	156	1049	955
Lead arsenate, 4 pounds Volck Concentrate, 1 quart Water, 100 gallons	560	723	2463	571	563	976
Kryocide, 4 pounds Dupont Spreader-Sticker, 3 ounces Water, 100 gallons	1057	373	303	1091	1504	866
Derris (4 per cent), 4 pounds Water, 100 gallons	549	949	1728	1176	935	1067
Dutox, 1 part Talc, 2 parts Flour, 2 parts	652	568	857	1077	402	711
Black Leaf 155, 1 part Talc, 1 part	438	517	875	1352	656	768
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	637	891	215	379	915	607
Check, no treatment	1080	950	1196	1514	1033	1155

A measure of the relative infestations in the various plots was obtained by counting the feeding punctures in leaves. For the first series of experiments this was done on June 8, or 2 weeks after the insecticides were applied. Holes were counted in 50 consecutive leaves in the center row of each plot. In order to avoid selection, the count was begun one full step from the nearest end of the center row. The data obtained are shown in table 12.

Feeding puncture records were taken in the second series of plots on September 2, 1942 which was 2 weeks after the last application of insecticides was made. The center leaflet was taken from 125 consecutive leaves in the center row of each plot. The leaflets were taken to the laboratory where the holes were counted carefully. The data obtained are presented in table 13.

The results of the two series of experiments correspond closely. In both cases the Alorco Cryolite and Dutox dusts yielded best results. Both were somewhat more effective than the Kryocide spray, indicating that dusts are more effective than sprays since each of the three materials contain fluorine as the killing agent. In both tests Derris spray was the least effective of all materials used.

The degree of control indicated in tables 12 and 13 is not high in any case, but a considerable amount of feeding had occurred before the treatments were applied. The feeding punctures that were present at the beginning of the experiments were necessarily included in the infestation counts. A limited survey made in the second planting indicated an average of 350 feeding punctures in 125 leaflets at the beginning of the experiment. If this figure is deducted from the mean for each treatment in table 13, the degree of control indicated is much great.

1943 EXPERIMENTS

In 1943 a series of dusting experiments for the control of the new brood was carried out in the same locality and in the same manner as in 1942. The strawberry field selected had been planted in the spring of 1942. Six dusts were tested and three applications were made of each material. The application dates were August 5, August 12, and August 20.

On September 2 the feeding punctures were counted in 100 consecutive leaves taken near the center of each plot. The materials used and the data obtained are shown in table 14.

The Alorco Cryolite and Dutox dusts again yielded best results. An analysis of variance in the data show that at odds of 100 to 1 both were significantly better than any other treatment. Alorco Cryolite seemed somewhat more effective than Dutox, although the difference can not be considered significant. The data in table 14 indicate a control of 71.3 per cent with Alorco Cryolite, but, when an allowance is made for the injury present when the first dust was applied, a higher degree of control is evident.

On August 20 and again on September 2, by walking across the plots back of the label stakes, each plot was rated from 1 to 5 according to the degree of injury apparent. The data obtained in both cases correspond in a general way with that shown in table 14. The injury in the plots that received cryolite and Dutox was so much reduced that their improved condition made them readily apparent without consulting the label stakes.

TABLE 14.—Feeding puncture records taken September 2, 1943 from 100-leaf samples from each replicate of plots dusted to control strawberry leaf beetle

Materials used	Replications					Mean
	A	B	C	D	E	
Lead arsenate, 1 part Hydrated lime, 4 parts	3272	2696	1473	940	1270	1930
Dutox, 1 part Talc, 2 parts Flour, 2 parts	957	549	627	363	293	558
Alorco Cryolite, 1 part Talc, 2 parts Flour, 2 parts	969	466	487	244	292	492
Calcium arsenate, 1 part Hydrated lime, 4 parts	1950	2250	995	1485	717	1479
Derris root (4 per cent), 1 part Talc, 7 parts	2352	1501	1640	1166	923	1516
10% Pyrocide dust	1445	1408	1291	1466	1342	1390
Check, no treatment	1877	1700	1313	2439	1241	1714

CONTROL MEASURES RECOMMENDED FOR THE STRAWBERRY LEAF BEETLE, PARIA SP.

The most effective and most economical control measures for *Paria* sp. consist in the following cultural practices:

1. Old strawberry beds should be plowed down carefully immediately after the second crop is harvested.
2. New plantings should be set on uninfested ground located at some distance from old plantings.
3. Avoid planting strawberries adjacent to woodlands or similar areas that provide excellent hibernating quarters for adult beetles.

If a leaf beetle population develops through failure to employ the above procedures or for any other reason, much damage can be avoided by dusting the plants with either cryolite or Dutox diluted with 2 parts talc and 2 parts flour. Since most damage usually occurs during August, three applications should be made at weekly intervals beginning early in the month.

Insecticidal treatments, however, are not wholly satisfactory. They should be employed only as a temporary measure to protect the plants until the population can be destroyed by plowing down the heavily infested planting when the insect is in the larval stage.

THE GRAPE COLASPIS, *COLASPIS BRUNNEA* FAB.

As has been indicated previously, the other rootworm sometimes found on the roots of strawberry in Ohio is known as the grape colaspis. It carries this name because it is often found feeding on the roots of grapes.

The adult beetle is a little larger than *Paria* sp. and measures about 3/16 of an inch in length. It is of a uniform yellowish-brown color. The most damage to strawberries in Ohio is caused by the adults feeding on the leaves. Two strawberry plantings were observed in July, 1939, that were damaged by this insect.

Forbes (8, 9) states that adults have been collected in Illinois from June 22 to September 14, but they are most abundant in July and August and are not found in winter.

Although strawberry plants are no doubt injured by the adult beetles more often than other plants, the beetles feed occasionally on a variety of hosts. They have been taken (8, 9, 1, 2) on the following plants: strawberry, grape, bean, buckwheat, corn, clover, willow, apple, pear, beets, dock, tick-trefoil, muskmelon, New Jersey tea, cowpea, sugar beet, potato, watermelon, okra, roses, plums, wild hop, and Virginia creeper. Young corn may be damaged seriously by the adults.

In addition to grape and strawberry, the larvae have been found feeding on the roots of red clover, alsike clover, sweet clover, soybeans, timothy, June grass, and Mexican drop seed (9, 1).

Eggs are laid in summer and fall. Chittenden (3), in describing the eggs, states that they are approximately ½ millimeter long and about 2½ times as long as wide. They are often deposited in irregularly placed clusters of 13 or more.

The newly hatched grubs feed for a while during the fall and live over winter as partly grown larvae (1). Most of them move downward below the line of heaviest frost during the winter and return to the roots when warm weather appears where they feed until mature. They usually begin pupating early in June and soon begin emerging as adults. Only one generation appears each year.

CONTROL MEASURES FOR THE GRAPE COLASPIS ON STRAWBERRY

Damage caused by *C. brunnea* on strawberries differs from that caused by *Paria* sp. in that the former feeds on the newly set plants only; whereas, the latter usually causes trouble only after a planting has been permitted to stand for more than 2 years. Apparently, damage caused by *C. brunnea* appears when infested ground is plowed down and immediately planted to strawberries. If an infested field of strawberries, timothy, clover, or other legume is plowed in the spring, a sufficient portion of the *C. brunnea* larvae may survive and transform to beetles to cause trouble on the young strawberry plants. However, if such infested fields are plowed down in the fall (4), the larvae are not likely to survive and trouble seldom occurs.

Inasmuch as damage by this insect appears at widely separated and unpredictable intervals, it seems unlikely and unnecessary that growers should always observe the precautions listed in the preceding paragraph. However, when the beetles become sufficiently abundant to cause trouble they can be controlled effectively with the dusts suggested for use against *Paria* sp. One application of a dust made up of 1 part Dutox, 2 parts talc, and 2 parts flour effected an 88 per cent control in 1939. During the same year a grower effectively stopped further injury by dusting the plants heavily with lead arsenate and lime mixed at the rate of 4 pounds of the poison and 50 pounds of lime.

THE STRAWBERRY CROWN BORER,

TYLODERMA FRAGARIAE (RILEY)

Damage from the strawberry crown borer has not been widespread in Ohio in recent years, but it is capable of causing much trouble. Several injured strawberry fields have been observed by the writer. A planting which comprised several acres was rendered worthless in 1942. It was set in the spring of that year, and when visited in June nearly every plant was found to be infested with borers. Although relatively few plants were killed, growth was almost completely checked and no runners were formed. The planting was plowed down later in the summer.

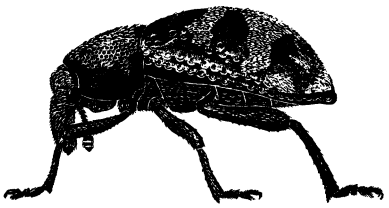

Fig. 7.—Strawberry crown borer adult. (Drawing by R. W. Rings)

The crown borer is widely distributed throughout the country and is no doubt a native American insect. In addition to the cultivated varieties of strawberry it feeds on wild strawberry and cinquefoil (*Potentilla canadensis*).

The adult is a small curculio or snout beetle (fig. 7) slightly less than ⅛ inch in length. When it first changes to the adult stage it is light brown in color, but soon becomes dark, and three irregular dark spots appear on each wing cover. The hind wings are dwarfed and for that reason the insect cannot fly. It must either crawl from the host plant in which it develops or it must be carried by artificial means in order to establish a new infestation. For these reasons new plantings of clean plants located some distance from infested plantings or beds of wild strawberries or cinquefoil are seldom attacked. A new infestation also spreads relatively slowly across a planting.

The adults appear in late summer and fall and hibernate in the soil or in debris around the plants. They become active quite early in the spring and may feed on the foliage before egg laying begins. They usually start depositing eggs in late March or April and may continue until August, although usually the largest number are deposited in June. For the most part, the eggs are laid on the crown of a strawberry plant near the base of a leaf stem. The length of time required for the eggs to hatch varies with weather conditions. They may hatch in 8 or 9 days in warm weather, but in cool weather 3 weeks or more may be required.

The damage is caused by the larva or grub which bores into the crown (fig. 8) and feeds on the interior. Sometimes the crown is hollowed out so completely that growth is checked and the plant killed.

The larva is a white, legless grub and when full grown measures approximately ⅛ inch in length. When mature it changes to a pure white pupa (fig. 7) inside the crown of the plant. After about 10 days, the pupa changes to an adult beetle. The adult feeds for a period of several days inside the burrow, during which time the body hardens and attains the dark brown color. It eats an opening to the outside, emerges, and may feed for a time on the foliage before seeking hibernating quarters in the soil or under debris near the plants. The adults are seldom seen by growers because their color blends well with the color of the soil and debris and because when feeding they are nearly

Fig. 8.—Strawberry crowns cut open to show the larva of the strawberry crown borer and its injury

always concealed by the foliage. When disturbed, they immediately drop to the ground. The earliest adults may appear in June, but the largest numbers usually appear during August. An occasional individual may hibernate as a larva and change to the pupal stage early in the spring but by far the largest number hibernate as adults. Only one generation appears each year.

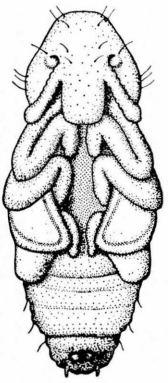

Fig. 9.—Crown borer pupa. (Drawing by R. W. Rings)

CONTROL MEASURES

Inasmuch as the crown borer adults cannot fly and can mature only on strawberry and cinquefoil, they can be controlled readily by adopting the following cultural practices.

1. Ritcher (22) has shown that the beetles can crawl 300 yards without a source of food. A new planting therefore should be set at a distance of more than 300 yards from an infested planting.
2. A new planting should be set on ground that has not contained infested strawberry plants or cinquefoil during the preceding year.
3. Be sure that no eggs, larvae, or adults are transferred with new plants.
4. Destroy all wild strawberry plants and cinquefoil within 350 yards of the strawberry planting.
5. Plow down each planting after the second crop is harvested.

WHITE GRUBS

White grubs are among the major pests of strawberry plants and also are among the most difficult of the group to control. They are large, thick-bodied, dirty-white worms which are approximately 1 and ½ inches long when mature. They feed on the roots of a variety of plants, and on strawberry they often cut the plants completely off just below the crown. When dug from the ground they always lie in a curved position (fig. 10).

Fig. 10.—A strawberry plant that was killed by a white grub.

The most severe damage occurs during the summer of the first year in a strawberry planting (fig. 11). Frequently one-third or more of the plants are killed. Damage is most likely to occur when strawberries are planted on newly plowed sod.

White grubs are the immature forms or larvae of May beetles or "June bugs." The beetles are dark brown in color and vary from ½ to ⅞ of an inch in length. They are often attracted to lights, and during June may sometimes be seen in considerable numbers around street lights. They remain concealed in the soil during the day, but at dusk they emerge and fly to various ornamental or forest trees to feed. Sometimes they congregate in such numbers on isolated trees as to almost completely defoliate them. Just before dawn they return to the soil.

Fig. 11.—A portion of a strawberry row that was severely attacked by white grubs.

Eggs are deposited in the soil at a depth of from 1 to several inches. Each is surrounded by a small ball of earth which is held together with a glutinous secretion. They are apparently deposited most abundantly in sod that has not been disturbed for years, although they occur in almost any type of soil sufficiently porous to permit the female beetles to crawl into it.

The eggs hatch in 3 or 4 weeks and the tiny larvae feed largely on vegetable matter in the soil during the remainder of the first season. When cold weather appears, most species of white grubs migrate downward below the frost line where they remain until the spring of the following season. They spend all of the next summer feeding on the roots of plants and during the second winter they continue as larvae below the frost line in the soil. The third year they return to the plant roots and feed until late June or July, when they change to pupae in small earthen cells. The adults emerge from the pupal cases a few weeks later but remain in the soil until spring. Thus, eggs are laid every third year and, since the beetles are abundant at 3-year intervals, severe damage usually occurs only every third year.

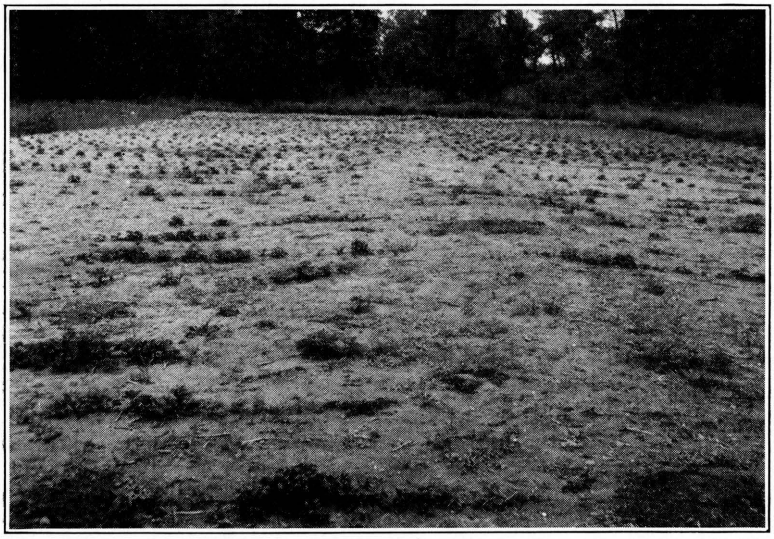

Fig. 12.—A strawberry planting that was ruined by larvae of the bumble flower beetle, *Euphoria inda*.

However, there is one species which completes its development and changes to the adult stage in one year. It is known as the "annual white grub." This species attacks the roots of certain grasses and may sometimes become sufficiently abundant to cause severe damage; it seldom causes trouble in strawberries.

In 1928 a strawberry planting was seen near Greensburg which was severely injured by grubs. It was learned later that much of the injury was caused by larvae of the bumble flower beetle, *Euphoria inda* (L.) (figs. 12 and 13). This insect is closely related to the May beetles and the larva works in the same manner, but it completes its life cycle in 1 year as does the annual white grub. However, it so seldom becomes sufficiently abundant to cause trouble that it has not previously been reported as a pest.

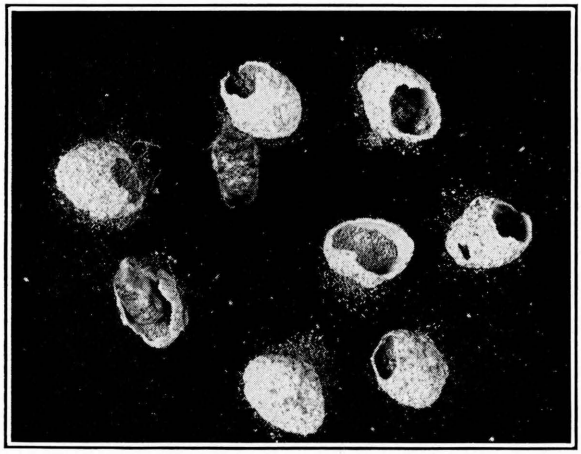

Fig. 13.—Bumble flower beetles and their cocoons, taken from the strawberry field shown in Figure 12.

CONTROL MEASURES

Strawberries should not be planted on newly plowed sod nor in any field in which grubs are abundant. In areas where injury occurs in spite of these precautions, it can be avoided by applying lead arsenate to the soil before the plants are set. A good method for making the application of lead arsenate is to mix 5 or 10 pounds with a cubic foot of dry soil or sand and spread this evenly over 1000 square feet of surface. It should then be mixed with the upper layer of soil. Such a treatment remains effective for a number of years.

The expense can be reduced by treating strips of soil one foot in width and planting the berries in the middle of the treated area. The arsenical should be applied in the same manner, using 5 or 10 pounds in 1000 feet of row.

T. W. Kerr, Jr. (15) of the New York Experiment Station suggests the following procedure: "lead arsenate is mixed with dry sand at the rate of 1 pound of arsenical to 20 pounds of sand. The mixture is stirred thoroughly in a barrel mixer or other suitable receptacle until the arsenical is evenly distributed throughout the mass. Application of the sand-arsenical mixture is made at the time when the plants are set out in the field, one handful (approximately 1.5 ounces of the material) being scattered into the hole made in the moist soil before placing the plant roots therein."

Mr. Kerr suggests however that "further investigational work is necessary to determine whether the application of sand-arsenical mixtures to the roots of strawberry plants is instrumental in reducing the yield of fruit." This method was tested by the writer in the spring of 1942 in a field where grubs were causing no trouble. During the early part of the season the treated plants appeared less vigorous than those not treated and a few plants were killed by the treatment. At the end of the growing season, however, the entire planting was in good condition.

SPITTLE BUGS

White, frothy, irregular masses ½ inch or more in diameter covering small green insects sometimes appear on the stems and leaves of strawberries. The insects are known as spittle bugs because of the peculiar spittle-like substance with which they cover themselves. They are often seen in meadows and on plants in uncultivated fields.

Spittle bugs have sharp beaks with which they pierce the stems of plants and sap the plant juices. The nymph or young stage produces the frothy material and it remains in this protective substance until the adult stage develops. The frothy mass then dries and the adult moves about over the plants. Only one generation appears each year.

Spittle bugs were observed causing damage to strawberries in eastern Ohio in 1940, and specimens, that were sent to the Bureau of Entomology and Plant Quarantine at Washington, D. C., were identified by Dr. P. W. Oman as *Philaenus leucophthalmus* (L.). The frothy masses were observed on more than half of the strawberry plants early in June and from 1 to 12 nymphs were found in each mass of material. By the middle of June many of the insects had reached the adult stage, and by the first of July most of the frothy masses had disappeared.

Driggers and Pepper (5) and Garman (11) state that the insect passes the winter as an egg in or on the stem of the plant. The nymphs appear in April and May and complete their development in from 4 to 8 weeks. Mating and egg laying begins in July and may continue as late as October.

CONTROL MEASURES

Excellent results were obtained in a series of dusting experiments carried on in eastern Ohio in 1940 with one application of a powdered derris root-talc dust containing 0.5 per cent rotenone. The dust was applied on June 8 and when the records were taken on June 14 it was found that 87 per cent of the nymphs had been killed. Driggers and Pepper reported similar results in 1935 (5). A thorough application is necessary, however, because the dust must come in contact with the spittle in order to kill the insects.

RED SPIDER

The common red spider, *Tetranychus bimaculatus* Harvey, (7) sometimes attacks strawberry plants. The adult is quite small, measuring approximately 1/50 of an inch in length. Its color varies from pale greenish-yellow to dark crimson, usually marked with dark spots.

The red spider is widely distributed and attacks a variety of plants including truck crops, fruit trees, and ornamental plants. It is often a pest in greenhouses. By means of sharp lance-like mouth parts which are thrust well into the leaf, the mites siphon out the plant juices which causes the leaves to discolor and curl. Feeding and egg deposition occur on the under side of the foliage and in heavy infestations a tangle of fine silken webs occurs there. The webs apparently serve as a protection from enemies, as well as from hard rains.

The length of the life cycle varies with seasonal and weather conditions but may be completed in approximately 2 weeks. Reproduction may be continuous from early spring until late fall.

CONTROL MEASURES

The red spider seldom becomes sufficiently troublesome on strawberry to warrant control measures. However, when a heavy infestation develops it can be controlled with sprays or dusts containing either rotenone or a dinitro compound as the killing agent. These materials, as well as some of the other commercial preparations commonly used for the control of red spider in greenhouses, are satisfactory when used according to the manufacturer's recommendations. Two applications should be made within a period of from 5 to 7 days in order to kill any individuals that were in the egg stage at the time of the first application.

MYODOCHUS SERRIPES OLIV.

Early in August 1936 a peculiar type of injury to the fruits was observed in a planting containing 10,000 ever-bearing strawberry plants near Attica, Ohio (20). The appearance of the injury indicated that the berries were being damaged by an insect with a long sucking beak. Injured berries became soft and soon were covered with mold. The only insect that could be found in sufficient numbers to cause the trouble was a Lygeid, which was later identified by Dr. H. G. Barber of the Bureau of Entomology and Plant Quarantine as *Myodochus serripes* Oliv. (fig. 14).

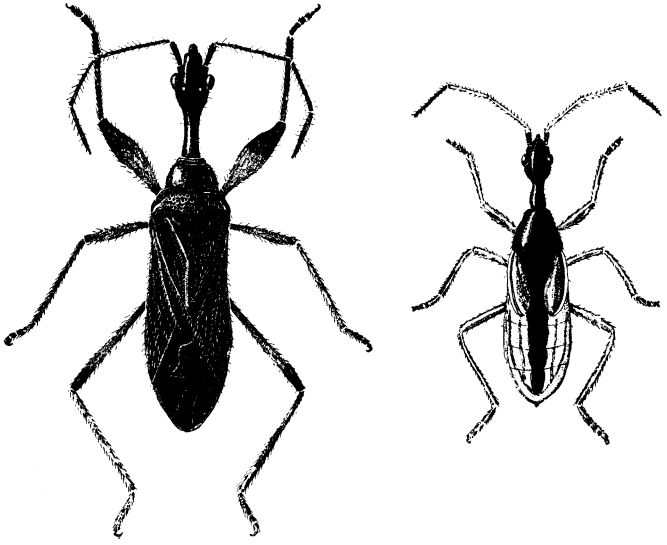

Fig. 14.—*Myodochus serripes* Oliv. adult, and fourth instar nymph. (Drawing by R. W. Rings)

It was first thought that *M. serripes* was of a type that feeds on other insects and was not responsible for the damage, but a review of the literature showed that it had been reported injuring strawberries in Maryland and in Virginia in 1899. Specimens were received at the Ohio Experiment Station

from Belmont County in 1898 with the statement that they were causing serious injury to ripening strawberries, but it was assumed at that time that some other insect was causing the damage.

Several times since 1936, *M. serripes* has been observed feeding on ever-bearing strawberries and in more recent years it has been reared in considerable numbers in cages containing strawberries. On August 7, 1941 many were collected on strawberry plants near Wooster. After examining several individuals under a binocular, it was found that the sexes could be distinguished readily (fig. 15). Consequently, males and females were placed in lantern-globe cages placed over ever-bearing strawberry plants which were growing in 9-inch pots. On September 5 many tiny nymphs were found in each of two cages. One cage was dismantled and approximately 100 nymphs were counted. On September 17 two newly hatched nymphs were placed in a stender dish for observation. A fresh strawberry leaf and ripe berries were kept before them at all times. They grew rapidly and the adult stage was reached in 18 days by one individual and in 19 days by the other. Later three individuals were reared from egg to adult in the same manner in 25 days. The humidity inside the container was quite high and the temperature was maintained at approximately 72 degrees F. Other nymphs of approximately the same age which were in cages in the insectary were not more than half grown when these became adults.

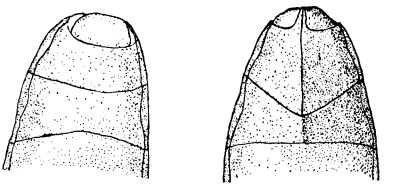

Fig. 15.—The ventral surface of the abdomen of *M. serripes*. A—male. B—female.

The eggs are quite small, measuring approximately 1 millimeter in length and 0.4 millimeter in width. They are translucent and almost colorless but become yellowish-red before hatching. They are cylindrical in shape with the anterior end flattened and the posterior end somewhat pointed. In breeding cages, the eggs were dropped indiscriminately in the sawdust mulch around the plants.

Measurements of the head widths of 53 nymphs of various sizes indicate that the insect goes through five numphal instars before reaching the adult stage. The first and second instars can be distinguished readily because of color changes, but the third, fourth, and fifth instars are similar in appearance except for differences in size.

Attempts to keep the insects alive over winter have been unsuccessful, but it seems evident that they hibernate as adults. It appears that at least two generations occur each year. The insect has never been found in abundance except in July and August. In the writer's experience it has been a pest only of strawberries of the ever-bearing varieties.

No satisfactory control measure has been devised. In 1936 a dust containing rotenone and another containing pyrethrum were tested but the results were not satisfactory. Inasmuch as the eggs are deposited in the litter, the type of mulch employed may have an influence on the population. In the cases where severe injury was observed, a sawdust mulch had been used.

STRAWBERRY PESTS OF MINOR IMPORTANCE IN OHIO

Leaf Rollers.—In addition to the common strawberry leaf roller discussed previously, five other species of leaf rollers have frequently been reared from folded strawberry leaves. They have been found most plentiful during May and July but have never been sufficiently abundant to cause economic damage. The five species that have been recorded are: *Cacoecia rosaceana* Harris, *Amelia pallorana* Robinson, *Sparganothis sulfureana* Clemens, *Olethreutes cespitana* Hbn., and *Platynota flavedana* Clemens. The control measures suggested for the strawberry leaf roller would doubtless be effective against these species.

The Strawberry Weevil, *Anthonomus signatus* Say.—This weevil is about 1/10 of an inch long, with the head prolonged into a slender curved snout about half as long as the body. The beetles leave their winter quarters in fence rows and woodlands about the time the first strawberry blooms appear. Eggs are deposited in opening blossoms or in buds that are nearly mature. The stem of the bud is then cut so that it hangs by a mere thread or falls to the ground. The larva develops inside the bud and reaches maturity in 3 or 4 weeks. Only one brood appears each year. No damage by this insect has been observed in Ohio by the writer. Apparently injury is most likely to occur when strawberries are grown adjacent to woodlands or other suitable hibernating quarters.

Strawberry Root Weevils.—Six strawberry root weevils have been reported (26) causing severe damage in Oregon and Washington. All have similar life histories and habits. One species, *Brachyrhinus ovatus* L., has been collected in Ohio in the larval stage on strawberry roots and reared to the adult stage at Wooster. Also, specimens of this species have been received at the Ohio Agricultural Experiment Station from northeastern Ohio, with the report that they entered a dwelling house in considerable numbers. No commercial damage to strawberries has been observed by the writer.

The beetles are dark brown or black and are approximately ¼ inch long. The wing covers are tightly grown together and the insect is unable to fly. The chief damage is caused by the larvae in feeding on the roots and crown of the plant. Injured plants are stunted and discolored.

The cultural practices suggested for the control of the strawberry rootworms should help to hold this insect in check. In the Pacific Northwest where root-weevils are very troublesome, the most effective controls consist of poison baits.

The Strawberry Root Aphid, *Aphis forbesi* Weed.—This insect, one of the so called plant lice, lays its shiny black eggs on the stems and leaves of strawberry plants in late fall. The eggs hatch early in the spring and the young bluish-green aphids feed on the newly developed strawberry leaves. Wherever the aphids become abundant they are soon found by ants which carry them to the strawberry roots, where they feed by sucking the sap from the root tissues. A number of generations of wingless females are produced during the summer, but on the approach of cold weather winged forms again appear which emerge from the ground.

In setting new beds, the soil should be given a thorough and deep cultivation early in the spring to drive out the ants, and uninfested plants should be selected (23).

The Cyclamen Mite, *Tarsonemus pallidus* Banks.—This mite, which is so tiny that it is scarcely visible to the unaided eye, is primarily a pest on greenhouse plants, but occasionally it attacks strawberries. It feeds on the young unfolding leaves in the crown of the plant and causes a stunting and dwarfing of the leaves. Later it feeds on the blossoms and causes a distortion of the fruits. When the mite once becomes established, it is difficult to control. In setting a new planting it is important that plants be used that are free from mites (6).

Strawberry Sawflies.—Two species of sawflies, *Empria maculata* Nort. and *E. ignota* Nort., sometimes attack strawberries. *E. maculata* was reported causing damage near Cleveland in 1896 (25), but neither species has been troublesome in Ohio in recent years. The adult sawflies which have the appearance of tiny bees, appear quite early in the spring and deposit eggs in the strawberry leaves. About the time of first bloom, tiny green larvae or slugs issue from the eggs and feed on the foliage. Much of their feeding occurs at night. When the larvae reach maturity, which usually occurs during June, they measure approximately ¾ inch in length. They then enter the soil where they remain until the following spring. The sprays and dusts suggested for the control of the strawberry leaf roller will control these insects also.

Cutworms.—Cutworms are the larvae of a large group of night-flying moths and occasionally are found causing trouble in strawberry plantings. They feed chiefly at night and hide during the day under clods or debris near the plants. Some species feed at the surface of the soil and others attack the leaves and blossoms. Strawberries should not be planted in newly plowed sod. Cutworms, like white grubs, are usually abundant in such soil.

Usually the proper use of poisoned bran bait will control cutworms satisfactorily. The following formula will provide bait for 2000 square feet of soil surface: Mix, while dry, 1½ pounds of wheat bran and 1 ounce of Paris Green, white arsenic, or sodium fluosilicate. Dissolve 3 fluid ounces of syrup in 1½ pints of water. Add the syrup solution to the bran-poison mixture slowly while stirring. The bait should be scattered evenly along each strawberry row in late afternoon or early evening. Thus, the bait will be moist and fresh when the cutworms begin feeding at night. The ideal bait is one in which the flakes are moist but not wet enough to stick together.

LITERATURE CITED

1. Bigger, J. H. 1928. Hibernation studies of *Colaspis brunnea* (Fab.) Jour. Econ. Ent. **21**: 268-273.
2. Brisley, H. R. 1925. Notes on the Chrisomelidae (Coleoptera) of Arizona. Trans. Amer. Ent. Soc. **51**: 169.
3. Chittenden, F. H. 1897. Notes on certain species of Coleoptera that attack useful plants. U. S. D. A. Div. of Ent. Bur. **9** n. s.: 21.
4. Deay, H. O. 1942. Proceedings 21st Annual Meeting North Central States Entomologists.
5. Driggers, Byrley F., and B. B. Pepper. 1935. The spittle insect or frog-hopper. N. J. Agr. Exp. Sta. Bull. 593.
6. Edwards, W. D., and S. M. Zeller. 1938. Insect pests and diseases of strawberry in Oregon. Oreg. Agr. Exp. Sta. Bull. 357.
7. Ewing, H. E. 1914. The common red spider, or spider mite. Oreg. Agr. Exp. Sta. Bull. 121.
8. Forbes, S. A. 1900. Noxious and beneficial insects. 21st. Rept. State Ent. of Ill., p. 125.
9. ————. 1903. Noxious and beneficial insects. 22nd. Rept. State Ent. of Ill.
10. Garman, H. 1890. Some Strawberry Pests. Ky. Agr. Exp. Sta. Bull 31.
11. Garman, Phillip. 1921. The grass feeding frog-hopper or spittle-bug. Conn. Agr. Exp. Sta. Bull. 230.
12. Gossard, H. A. 1911. Fall manual of practice in economic zoology. Ohio Agr. Exp. Sta. Bull 233: 149.
13. Haseman, L. 1928. Controlling the insect pests of strawberries. Mo. Agr. Exp. Sta. Cir. 168.
14. ———— and K. C. Sullivan. 1927. The strawberry crown borer. Mo. Agr. Exp. Sta. Bull. 246.
15. Kerr, Jr., Theodore W. 1941. Control of white grubs in strawberries. Cornell Univ. Agr. Exp. Sta. Bull. 770.
16. Lamerson, Paul G., and Ralph L. Parker. 1939. Control of the American strawberry leaf roller, *Ancylis fragariae* in the Lower Missouri River valley. Jour. Econ. Ent. **32**: 824-828.
17. McBride, O. C. 1924. Injurious pests of strawberries. Mo. Agr. Exp. Sta. Bull. 215.
18. McGregor, E. A., and F. L. McDonough. 1917. The red spider on cotton. U. S. D. A. Bur. of Ent. Bull. 416.
19. Neiswander, R. B. 1938. The strawberry leaf roller, *Ancylis comptana* (Froel.) in Ohio. Jour. Econ. Ent. **31**: 382-385.
20. ————. 1941. Five troublesome strawberry pests. Proc. 74th Ann. Meeting Ohio State Hort. Soc., pp. 128-136.

21. Osborn, Herbert. 1916. Studies of life histories of frog-hoppers of Maine. Maine Agr. Exp. Sta. Bull. 254.

22. Richter, P. O. 1939. The strawberry crown borer, *Tyloderma fragariae* (Riley). Ky. Agr. Exp. Sta. Bull. 389.

23. Smith, W. W. 1943. Strawberry insects and their control in Missouri. Mo. Agr. Exp. Sta. Bull. 463.

24. Stedman, J. M. 1901. Two insects injurious to strawberry. Mo. Agr. Exp. Sta. Bull. 54.

25. Webster, F. M. 1896. Some particularly destructive insects of Ohio. Ohio Agr. Exp. Sta. Bull. 68: 33-35.

26. Wilcox, J., Don C. Mote, and Leroy Childs. 1934. The root weevils injurious to strawberries in Oregon. Oreg. Agr. Exp. Sta. Bull. 330.

This page intentionally blank.